Intern. J. Neuroscience, 117:295–299, 2007
Copyright © 2007 Informa Healthcare
ISSN: 0020-7454 / 1543-5245 online
DOI: 10.1080/00207450500535834

informa
healthcare

Int J Neurosci Downloaded from informahealthcare.com by University of Western Ontario on 07/07/11
For personal use only.

Brief Communication

BRIEF EXPOSURES TO THETA-BURST MAGNETIC FIELDS IMPAIR THE CONSOLIDATION OF FOOD-INDUCED CONDITIONED PLACE PREFERENCE

J. J. DELPARTE
M. A. PERSINGER

Behavioral Neuroscience Laboratory
Laurentian University
Sudbury, Ontario, Canada

Theta-burst magnetic fields (1 μT) designed to mimic electrical stimuli employed *in vitro* to affect long-term potentiation have been previously shown to impair the acquisition of conditioned fear. In the current study, the authors were interested in investigating whether similar magnetic fields could affect the consolidation of food-induced conditioned place preference. Fourteen male Wistar rats were exposed to a theta-burst magnetic field (1 s pulse of 5 trains of an LTP-evoking pattern) continuously or with either a 5 s or 10 s interstimulus interval for 15 min immediately following 6 daily conditioning trials (15 min/day) in a place preference apparatus. Testing demonstrated the durations in the food-paired chamber was significantly shorter for all of the magnetic field–exposed groups compared to the sham-exposed group (they remained for longer periods in the food-paired chamber, typical of normal rats). In addition, the group exposed continuously to the LTP-magnetic field (1-ms interstimulus duration) displayed the least time in the food-paired chamber. The treatments explained 80% of the variance in durations within the experimental setting. These results suggest that exposures to theta-burst magnetic fields elicit amnesic effects for contextual stimuli.

Keywords conditioned place preference, long-term potentiation, magnetic fields, rats

Received 29 October 2005.

Address correspondence to M. A. Persinger, Behavioral Neuroscience Laboratory, Laurentian University Sudbury, Ontario P3E 2C6, Canada. E-mail: mpersinger@laurentian.ca

RIGHTSLINK

Int J Neurosci Downloaded from informahealthcare.com by University of Western Ontario on 07/07/11
For personal use only.

It has previously been demonstrated that brief whole body exposures to theta burst patterned magnetic fields impair acquisition of contextual fear conditioning (McKay et al., 2000) and fear-conditioned analgesia (Stewart & Persinger, 2000). Exposures to the same pattern magnetic field in a discrete fear conditioning paradigm with a tone did not impair the task acquisition (McKay et al., 2000). This study also showed that the impairments were specific to the pattern used as intensity matched sine waves failed to elicit impairments in a contextual fear conditioning paradigm.

The current study was designed to discern whether a theta burst magnetic field could impair memory consolidation in a different learning paradigm: conditioned place preference. In order to further investigate the specific parameters needed to elicit a maximal effect, variations in the interstimulus interval (ISI) between pulse presentations were employed. Aside from a continuous magnetic field presentation (1 ms ISI), 5 s and 10 s ISIs were used as these have been found to elicit long-term potentiation in the entorhinal cortex when applied electrically (Yun et al., 2002).

Fourteen individually housed male Wistar rats aged 4 to 5 months served as subjects. Rats were food-deprived the day before the training period and only received food every second day in the conditioned place preference (CPP) apparatus. Water was available *ad libitum*. The magnetic field exposure system used has been previously described elsewhere (Martin & Persinger, 2003). Briefly, the apparatus was composed of a 25 cm $\times$ 25 cm $\times$ 25 cm Plexiglas chamber with two horizontally aligned electromagnets on opposite sides. The electromagnets were composed of 25 cm iron nails wrapped 1,050 turns with 22 gauge enameled copper wire over 19 cm. These were placed at the center of two sides of the chamber, 5 cm from its base ($\sim$3 cm of corn cob bedding) in an East-West geographic orientation ($\pm 5^{\circ}$). The electromagnets were connected to a Zenith XT personal computer through custom made digital to analog converter that transformed a series of values between 0 and 255 to voltages ranging from $\times 5$ to $+5$ volts with 128 representing neutral polarity. For the waveform generated in this experiment, the values ranged from 125 ($\sim \times 0.12$ volts) to 250 ($\sim$4.77 volts).

The magnetic field generated was similar as previously employed in this laboratory and found to have amnesic effects in a contextual fear conditioning paradigm (Martin et al., 2000; Martin and Persinger, 2003). The pattern was composed of an initial priming pulse followed by a delay (theta) and four pulses at about 60 Hz, resulting in a 4.5 Hz (theta) presentation. This pattern was repeated 5 times and followed by an interstimulus interval (ISI). Rats were assigned randomly to either a sham condition or one of three ISI conditions:

RIGHTSLINK

Int J Neurosci Downloaded from informahealthcare.com by University of Western Ontario on 07/07/11
For personal use only.

1 ms (continuous), 5,000 ms, or 10,000 ms. All exposures were 15 min in duration. The intensity of the magnetic field generated was measured to be between .20 μT and 1.71 μT with Metex 3800 multimeter and magnetic sensor probe (Electric Field Measurements, Stockbridge, MA).

The CPP apparatus consisted of two chambers (30 cm $\times$ 40 cm $\times$ 30 cm deep) separated by a partition in which a guillotine door (10 cm $\times$ 10 cm) was installed. The chambers were made of oriented strand board (OSB) painted with alkyd paint. One chamber was painted with alternating black and white vertical lines (3 cm) whereas the other chamber was painted with horizontal lines (3 cm). The door and the floor of both chambers were painted white.

Each day, for six days, rats were introduced to one of the two chambers in the presence or absence of food (Purina rat chow) for 15 min. Approximately 50 g of food was placed in a plastic container (10 cm diameter $\times$ 3 cm deep) in the back corner furthest from the midline of the chamber. Rats were in a food-paired chamber every second day whereas on the other days, they were placed in the opposite chamber without food. Rats in each field condition were counterbalanced for day of food pairing (even days or odd days) and for paired chamber (vertical or horizontal). Chambers were cleaned with 10% ethanol and allowed to dry before each trial. Following 15 min in the CPP apparatus, rats were brought to a separate room where they were exposed to one of the three complex magnetic fields described earlier or a sham.

The day after the final pairing, rats were given full access to the CPP apparatus by lifting the guillotine door separating the two chambers. The rats were initially placed in the unpaired chamber and allowed to explore both chambers for 15 min while being videotaped. The videotapes were then viewed and the time spent in each chamber was recorded. A rat was considered to be in a given chamber when both front paws had crossed the midline.

The results were analyzed by two-way analyses of variance (one within and one between level) to investigate differences in sec (time) spent in chambers as a function of treatments. *Post hoc* analyses using Tukey's ($p < .05$) for between subject variables and paired *t*-tests ($p < .05$) for within subject variables were conducted in order to determine the source of the effects. Two outliers were excluded from the analysis.

The means and standard errors of the means ($\pm$SEM) for time spent in the food-paired and unpaired chamber for the four treatment groups are shown in Figure 1. There was a significant interaction between chambers and treatments [$F(3,12) = 10.57$; $p < .01$; $\text{eta}^2 = 80\%$]. *Post hoc* analyses using paired *t*-tests revealed that the source of the interaction was due to the sham-treated group spending significantly more time in the paired chamber

RIGHTSLINK

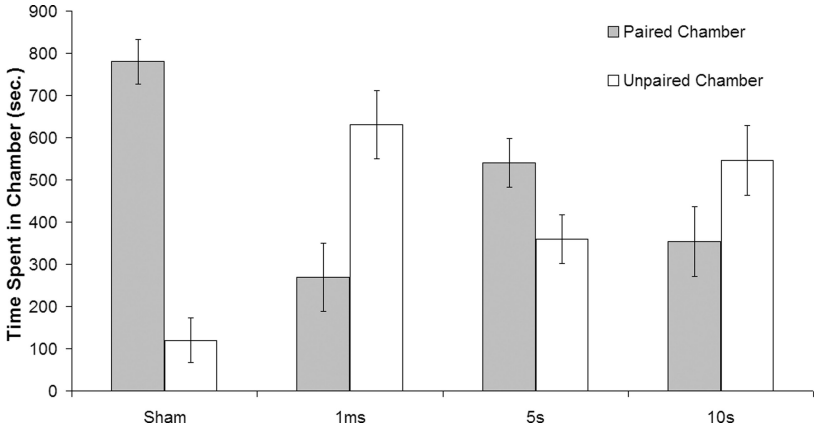

Figure 1. Duration (in s) in the food-paired and non-food-paired chambers for rats on the test day after 6 daily conditioning sessions followed by 15 min whole body exposures to a theta burst magnetic field either continuously (1 ms), once every 5 s, or once every 10 s for 15 min, or to the sham field condition.

than the unpaired chamber [$t(2) = 6.16$; $p < .05$) whereas the other groups did not differ significantly ($p > .05$) in the time spent in either chamber. Tukey's further revealed that the 1 ms ISI-treated group [$F(1,5) = 27.69$; $p < .05$], 5,000 ms ISI-treated group [$F(1,5) = 9.36$; $p < .05$] and 10,000 ms ISI-treated group [$F(1,5) = 18.91$; $p < .05$] spent significantly less time in the paired chamber relative to the sham-treated group. However, the 1 ms ISI-treated group spent significantly less time in the paired chamber than the 5 s ISI-treated group [$F(1,5) = 7.50$; $p = .05$].

The current study demonstrated that brief exposures to a theta burst magnetic field can impair the consolidation of conditioned place preference. Not only did all the different ISI conditions produce impairments, it was found that a shorter magnetic field exposure duration (15 min) than used in previous studies (McKay et al., 2000) was sufficient in producing the amnesic effects. Although the goal of investigating the effects of magnetic field exposure on learning is to find a temporal pattern that enhances learning, current research seems to indicate that an impairment of natural function is more likely to result than an enhancement.

REFERENCES

Martin, L. J., & Persinger, M. A. (2003). Spatial heterogeneity not homogeneity of the magnetic field during exposures to complex frequency-modulated patterns facilitates analgesia. *Perceptual and Motor Skills*, *96*, 1005–1012.

Int J Neurosci Downloaded from informahealthcare.com by University of Western Ontario on 07/07/11
For personal use only.

RIGHTSLINK

McKay, B. E., Persinger, M. S., & Koren, S. A. (2000). Exposure to a theta-burst patterned magnetic Feld impairs memory acquisition and consolidation for contextual but not discrete conditioned fear in rats. *Neuroscience Letters*, *292*, 99–102.

Stewart, L. S., & Persinger, M. A. (2002). Pretraining exposure to physiologically patterned electromagnetic stimulation attenuates fear-conditioned analgesia. *International Journal of Neuroscience*, *100*, 91–98.

Yun, S. H., Mook-Jung, I., & Jung, M. W. (2002). Variation in effective stimulus patterns for induction of long-term potentiation across different layers of rat entorhinal cortex. *Journal of Neuroscience*, *22*, 1–5.

Int J Neurosci Downloaded from informahealthcare.com by University of Western Ontario on 07/07/11
For personal use only.

RIGHTSLINK